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THE USE OF HYPOTHERMY IN NEUROSURGICAL OPERATIONS

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The problem of anesthesia in neurosurgery cannot be considered as finally solved at the present time. This especially pertains to the surgery of the deeper cerebral sections and hypophysis. As the result of trauma during these operations not infrequently serious reactions occur, sometimes leading to irreversible changes in the brain and death. This forces surgeons to find new methods of anesthesia to prevent such reactions. One of these methods which appeared in recent years is hypothermy (V. N. Shamov and I. M. Borodin, 1955; V. N. Shamov, B. A. Samotokin and I. I. Gólikov, 1956; I. M. Borodin, A. B. Gorbatsevich, L. V. Lebegev, A. G. Panashchenko, 1958; A. B. Gorbatsevich, 1958; Yugenar, 1955; Bigelou, 1958).

In this article, analyses of the application of hypothermy during the new surgical operations in 65 patients (39 male and 26 female) is given.

The method of investigation and general characteristics of patients.

Mainly patients with large tumors located in difficultly accessible regions of the brain underwent operations which used hypothermy. The removal of these tumors is bound as a rule with serious vegetative vascular reactions and the danger of massive hemorrhage. The composition of patients is given in a table.

Localization of the process and its character	Number of patients operated on
Tumors of the cerebral hemispheres (mainly those of the small process, malignant and deep tumors, parasagittal tumors, etc.)	31

Table continued

Localization of the process and its character	Number of patients operated on
Tumors of the fourth ventricle, cerebellum and the vermis cerebelli.	8
Tumors of the hypophysis.	16
Tumors of the third ventricle	2
Vascular lesions of the brain (aneurysms of Willis' circle, angiomae).	2
Other lesions of the nervous system. . . .	6

At various times during hypothermy we undertook simultaneous neurologic investigations with the registration of respiration, pulse arterial pressure, electrocardiograms and, in several cases, blood oxygen tension.

Of the various methods described in the literature, we have chosen the following: the evening before the operation (at 22 and 24 o'clock) patients get 0.1 g luminal and also 2-3 cc 2% solution of dimedrol intramuscularly. On the day of the operation, two hours before it begins, the patient again gets 0.1 g luminal, and one and one half hour before the operation a lytic mixture of the following composition is introduced intramuscularly: 2 ml 2.5% aminazine, (in several cases we applied diisopropylputrescine, a drug of the gangliolytic series investigated at the Department of Pharmacology of VMOLA by A. D. Panashchenko), 2 ml 2% dimedrol and 2 ml 2% eikodal.

Thirty minutes before the beginning of narcosis, 1 ml of 0.1% scopolamine (or atropine in the same dose) and 1 ml of 2% pantopone were introduced subcutaneously. Afterwards a vein incision is performed and the dropwise transfusion of saline solution with the addition of 1 to 2 ml lytic mixture is applied. Intubation is performed after intravenous introduction of 10 to 20 ml of 2% pentathal solution, thiopentathal and 4 to 5 ml of 2% ditalene. Before the tubing is introduced, the larynx is smeared with Hirsch's mixture. Ether-oxygen anesthesia is given in combination with nitrous oxide. After the occurrence of deep narcosis, the lowering of temperature in a tub with cold water is begun (6-8°C).

Cooling time usually ranged from thirty minutes to one hour; in separate observations this period lasted up to one and one half hours. Cooling is stopped at 32-33°C, but in the process of the operation, body temperature during the first 1-2 hours usually dropped continuously and

only after this is stabilized at 30 - 31°C. Only in the post-operative period does a rise in temperature begin. In several cases hypothermy was prolonged and this was achieved by the complementary injection of the lytic mixture.

Preparation for surgery.

Preparation for operations was conducted following the above mentioned scheme. No complications were observed in patients after the injection of neuroplegic mixtures, and in only twelve patients sinus tachycardia, which afterwards disappeared, was observed.

At the beginning of our investigations, when intubation of the trachea was performed without complementary local anesthesia of the naso-pharyngeal and laryngeal mucosa with Hirsch's mixture, we often observed reactions such as arrhythmia (mostly sinus), the inhibition of respiration and in two cases even the temporary cessation of breathing. The mentioned contra-indications developed because of mechanical irritation of the large reflexogenic area of the naso-pharynx and larynx. We did not succeed in fully eliminating such reflexive reactions in the intubation of the trachea, though at present such reactions are less pronounced. In all observations the transition from barbiturate narcosis to ether-oxygen anesthesia occurred without an excitation stage, and this was due to the use of neuroplegic drugs.

Early hypothermy was caused by the action of neuroplegic drugs acting on thermoregulatory mechanisms and lowering the metabolic rate; this was observed 40 - 90 minutes after the introduction of the lytic mixture. The body temperature was lowered by 0.2 - 0.5°C and then cooling in a tub of cold water was initiated. Immersion into the bath was undertaken only after the attainment of deep narcosis. Violation of this principle led to the occurrence of such undesirable reactions as an elevation of tonus in all muscle groups, muscular tremors, the appearance of "goose pimples" tachycardia and increased respiration. All of these signs demanded increased narcosis and the complementary usage of the neuroplegic lytic mixture. The loss of tendon reflexes served as a neurological sign that the patient was ready for immersion in the cold bath. Special significance is attached to testing for patellar reflexes - their absence indicates narcosis of sufficient depth.

The general diminution of muscular tonus, pink color of the mucous membranes and skin, quiet regular breathing (12 - 14 per minute), and steady pulse beat with a frequency of 90 - 110 per minute are indications of proper

cooling. As cooling proceeds, arterial pressure begins to lower. The ECG R-R¹ intervals lengthen and some lengthening in the P₂ sections are observed. No distortion of conductivity is observed.

Our experience points out that neurosurgical operations under hypothermy usually go on more quietly and smoothly than andlogical operations under other kinds of anesthesia. Despite the presence of trauma and the great seriousness of the operation brought about by the character of the pathology, we have never observed disruption of the vitally important functions because of events of catastrophic speed occurring in the process of surgery.

The method of surgery was as usual. Smooth tissues were infiltrated with novacain (100 -150 ml of 0.5% solution). Tension in the dura mater was not observed. Hemorrhage from the skull integuments and from the small cerebral vessels was, as well, minimal. This is quite understandable because in almost all cases in hypothermy a moderate arterial hypotension (70-90 mm of mercury) takes place. This cannot be said about hemorrhage from the large arterial venous trunks, especially from the branches of the arterial carotid artery or vein sinuses. Even under hypothermy such hemorrhages sharply complicate the surgical procedure and present a serious threat. Under hypothermy we succeeded in performing quite a number of major operations in which radical surgery was undertaken for the removal of deeply located, large brain tumors, often localized on both sides. For illustration we will give some examples.

1. Patient K. H., female, 38 years old, operated on 4/11/58 because of arachnoidendothelioma of the ophthalmic groove, which had spread under both frontal lobes. At temperature of 29°C of arterial pressure 70-55 mm and pulse 85 per minute, we succeeded in the radical removal of a tumor weighing 142 g with resection of part of the falci-form process. At the time of tumor removal (for 15 minutes) lowered arterial pressure was noted. Post operative picture was fair, and resulted in recovery.

2. Patient D., female, 30 years old, was operated 6/8/55 because of arachnoidendethelioma of the falci-form process with growth into both cerebral hemispheres. At body temperature of 30°C, bone plastic trepanation was performed and a tumor weighing 207 g was removed with resection of the falci-form process. While removing the tumor, to lessen hemorrhage the left carotid artery was squeezed. Arterial pressure was not determined through 6 hours. Post operative condition was fair.

3. Patient D., female, 31 years old, operated on 12/20/54 with body temperature 28.5°C because of a large hypophysis tumor. The whole operation including the removing of a tumor was performed smoothly without any change in pulse, breathing and arterial pressure.

4. Patient Ch., female, 22 years old, has had sub-arachnoid hemorrhagia twice. Angiography revealed aneurism of Willis' circle to the left in the place of departure of the posterior commissural artery. Operation was performed on 3/18/59 using hypothermy at body temperature 31°C. The aneurism sac was separated and tied. The operation was successful and postoperative condition fair, resulting in recovery.

These examples may be continued but we do not place the task before us of describing the advantage of operations under hypothermic conditions which are well-known from the literature. We do consider calling attention to some peculiarities of the hypothermy course and complications which may occur during neurosurgical operations under hypothermy which are of reasonable importance.

It is accepted that hypothermy considerably lowers the reactivity of the body including that to operative trauma. In connection with that, performed surgery should be analyzed from the point of the presence and degree of reactions of the cardiovascular system under hypothermy conditions. In 28/65 operations performed under hypothermy, no pathological reactions from the cardiovascular system were observed. During 22 observations little reactions were noted. This group comprised patients, the arterial pressure of whom was lowered by 20 - 40 mm in comparison with starting figures. As expressed reactions, lowering of arterial pressure to the level of 0 - 30 mm together with distortion of breathing rhythm and the occurrence of different kinds of arrhythmia (in 15 patients), were considered. For determination of the degree of reactions of the body to operative trauma, we mainly used indices of arterial pressure because they are most sensitive in comparison with breathing, pulse, temperature, data of the electrocardiogram and so on, which usually are stabilized during hypothermy.

During sections of the dura mater, reactions of the cardiovascular system manifested first of all in lowering of the arterial pressure, were noted. Avoiding these reactions succeeded by means of very well controlled anesthesia of the dura mater with 1% solution of novocain. Expressed lowering of arterial pressure was noted after removal of tumors from the falciform process or from the roof of the

cerebellum. In connection with that, a method of infiltration of the falciform process with novocain was worked out in the clinic and also introduction of novocain intradurally on the base of the brain during manipulations on the small process of the paracellar and so on (P. M. Panchenko), which should be an obligatory complement during any operation including those during hypothermy. The same point is supported by Pul and Kessler (1958) describing 40 operations during hypothermy. The strongest reactions in the form of sharp lowering of arterial pressure (sometimes to 0) were observed during massive hemorrhage rising during separation and removal of a cerebral tumor.

According to the literature, acute edema and cerebral swelling usually are not observed during hypothermy. In three hour observations, during operations for hypophysis tumor, however, this menacing complication developed. The body temperature of patients was then 29 - 30°C and maximal artery pressure ranged from 60-90 mm.

Our observations in this respect are not unique. Three similar complications were reported by Sedzilil and Dandy, 1958.

Hypophysis surgery under hypothermy.

Such operations were performed in twelve patients with hypophysis tumors and in one patient with cranial pharyngeoma. The reasons for cooling in such cases were the large dimensions of tumors and the weakened conditions of the patients.

Access to these tumors in all the cases was temporal, along the process of the basilar bone. The cooling phase in these patients ran rather quickly, on the average 45 minutes. Cooling usually was stopped at body temperature of 33 - 32°C, taking into consideration that afterwards cooling by 1.5 - 2°C would take place. Central distortion of thermal regulation in these patients in several cases led to considerably more lowering of body temperature. This peculiarity should be kept in mind in the time calculations of active cooling (in a tub).

Of the complications arising during surgery, in addition to the above mentioned acute rise in cerebral edema, in two patients stoppage of respiration occurred which required respiratory support. For patients operated for hypophysis tumors leaving the hypothermy stage took longer than for other neurosurgical patients, and was on the average 9 - 12 hours. As regards hypothermy, the operations were performed on the most serious group of patients, who often were considered as non-operative with hypophysis tumors, and the mortality among them was considerable (of 13 operated on, 7 died). In all cases the cause of death

was cerebral edema. In two cases pathologists especially found the presence of edema of the cerebral trunk. It should also be noted that in five cases death occurred between the second and third days after the operation, i. e., after leaving the hypothermic stage. This causes us to seriously consider the solution to the problem of supporting hypothermy in the cases of definitely arising reactions which occur most distinctly after operations on the hypophysis, where the most favorable results evidently may be expected from prolonged hypothermy.

Although we share the point of view of the Polish neurosurgeons, Bidzinsky and Vronsky (1957) concerning the increased sensitivity of patients with tumors of the hypophysis to cold, we cannot agree with them that for these patients hypothermy is contraindicated. In no one case was the phenomena of "irreversible hypothermy" observed in these patients.

After hypothermy.

This is characterized by increased body temperature of the patient and by gradual restitution of the reflectory functions of the CNS. This rule has exceptions, however. Thus, in ten patients out of 65, lowering of the temperature by 2 - 6°C continued even after the operation. In two of them the body temperature dropped to 26°C, and this required special measures in regard to the patients' leaving of the hypothermy stage. In such cases we applied subcutaneous administration of atropine, blood transfusion, intravenous injections of calcium chloride and warming of the patient. The remaining 55 patients gradually came out of the hypothermy stage after cessation of narcosis. In most cases this period lasted 5 - 8 hours and was extended sometimes up to 12 - 16 hours dependant on the seriousness of the operation and the depth of hypothermy. Taking into consideration the possibility of grave reactions arising in some patients after the operative period in connection with the character of the surgery, we especially extended the period of leaving hypothermy by the aid of the addition of the lytic mixture, and we also supported cooling by means of ice bags. Such tactics, especially in the case of rapidly leaving hypothermy, should be considered as verified.

During neurological observations we succeeded in establishing the sequence of restoration of the functions: at the beginning, i. e., after 2 - 4 hours after the operation, the muscular tonus increases; in this case increase of tonus while deep reflexes are absent is characteristic. At a temperature of 31 - 32°C deep reflexes are restored,

firstly in the posterior and afterward in the anterior limbs. During further thermal increase of the body up to 32 - 34°C, motor reactions and later verbal reactions in response to soliciting the patient occur. During 8 - 12 hours after the operation, in accord with body temperature rises to initial figures, complete restitution of functions of the nervous system takes place and no complications connected with hypothermy are observed (A. B. Gorbatshevich, 1958). In the cases in which mortality occurred no restoration of functions of the nervous system as described above were observed: the patients continued in the stage of hypotonia and the absence of reflexes despite some body temperature rise. They showed a gradually increasing respiratory and cardiovascular system distortion. Twenty-three out of 65 operated on died, 9 of them with tumors of the hemisphere, 2 with posterior skull groove, 7 with tumors of the hypophysis, 1 with lesions of the chiasma 2 with tumors of the third ventricle, 1 with vascular cerebral lesions and 1 patient with other ailments. Seven to twelve hours after the operation one patient died, eight died 13 - 24 hours after, nine died after 2 - 3 days, three died after 4 - 5 days and two died after 6 - 7 days.

As is apparent from the given data, death even under extremely serious condition of the patient usually did not occur earlier than the second half of the operation day, or on the second to third day, i. e., after the patient had left the hypothermic stage.

Conclusions

1. A deep inhibition of the central nervous system of defensive character which favors good results in many complicated surgeries of the difficultly accessible regions of the brain results from induced hypothermy.

2. Under hypothermy surgery is conducted more smoothly. Circulatory reactivity and other reactions are considerably less pronounced than when usual anesthetic methods are applied.

3. It is reasonable to somewhat prolong the hypothermic state with neuroplegic drugs and complementary cooling in major, traumatic operations (especially when complicated by massive hemorrhage).

4. The return of nervous system functions after hypothermy operations occurs without complications. Some idiosyncracies dependant on the basic pathological focus and the character of the surgery are possible.

5. Mortality from hypothermy surgery is caused mainly by the character of the pathology and its localization.

6. The presence of large tumors and their arrangement in the deeper sections of the brain, or with distribution over a large area of the cerebral tissue should be considered indication for hypothermy in neurosurgical practice. Hypothermy is contraindicated if cardiovascular and/or respiratory organ lesions are present.

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